WIRE Mission

Operations Agreement

Between the

Mission Operations Team (MOT)
and the
Infrared Processing and Analysis Center (IPAC)

October 11, 1998

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1 Introduction

1.1 Purpose

This document specifies and controls the operations interfaces between the WIRE Mission Operations Team (MOT) and the WIRE Infrared Processing and Analysis Center (IPAC). The MOT is responsible for the safe operation of spacecraft for the purpose of meeting the mission's science objectives while IPAC is the center for WIRE science planning and data analysis operations.

1.2 Scope

This Operations Agreement (OA) describes the protocol for the interchange of all data products and information between the MOT and IPAC for the successful and efficient conduct of the mission. Also included here is a discussion and agreement on the conduct of all MOT and IPAC activities not involving any interchange but that may effect each others operations.

1.3 References

1) Interface Control Document Between the Wide-Field Infrared Explorer (WIRE) Ground Data System (GDS) and the WIRE Principal Investigator (PI)

1.4 Document Changes

This agreement will become effective upon approval and will remain in effect throughout the operations phase of the mission. Any subsequent changes to this document must be approved by at least those granting original approval or their proxies.

2 IPAC Science Timeline Delivery and Format

2.1 IPAC will generate 7 day timeline sets according to the requirements listed in the GSFC to PI Interface Control Document (ICD, see Reference 1). Each file set shall consist of 7 individual files containing instrument command activities spanning a nominal 24 hour period. Timeline sets are delivered each day of the work week (Monday-Friday). For the L&EO/IOC mission phase IPAC will deliver timeline sets at least once per day, 7 days per week, or as long as the MOT and IPAC continue 7 day/week staffing. The time period from when timeline sets are created until they first become valid is summarized below and depicted in Figures 1-1 and 1-2:

Table 2-1 Science Timeline Validation Schedule

Mission Phase	Number of Days From Creation Until Valid
L&EO/IOC	same day
Normal Ops	~36 hours

2.2 Timeline file generation shall be completed by COB Pacific Time for use by the MOT the morning of the following workday (8 am Eastern Time). During the L&EO/IOC mission phase timeline file updates may be delivered at any time to the MOT with at least one set delivered each day. The following table outlines the required delivery schedule and priority for special timelines used only during the L&EO/IOC period.

Table 2-2 Delivery and Priority Schedule for L&EO/IOC Special Timelines

	IPAC Delivery	
Timeline	Priority	Schedule Requirement
No Slew	Highest*	L - 3 days
IOC Science	.	L + 12 hours
Gyro Calibration	.	L + 12 hours
Constraint	.	L + 24 hours
Cover Eject	Lowest	L + 24 hours

2.3 IPAC will be responsible for notifying the MOT of the availability and machine/directory of new timeline sets within an hour after they become available.

2.4 IPAC will notify MOT mission planning personnel and the WIRE Operations Leader in the event of any special timeline processing requirements prior to the expected ATS load generation by the MOT. Notification shall be contained within the availability notice for the timeline set.

2.5 IPAC will remove older timeline sets from the delivery directory after receiving acknowledgement of timeline retrieval by the MOT.

2.6 Notification of timeline availability and MOT acknowledgement shall be via email and also by the WIRE Electronic Forum during L&EO/IOC operations. During normal operations notification of timeline availability shall also be via telephone in the event that timeline files are not delivered at their nominal time as specified above.

2.7 IPAC will assume that notification of a new timeline set shall immediately commit the set to the ATS load generation process. Timeline updates after this point shall be accommadated on an as possible basis prior to actual uplink. Updates occurring after ATS uplink to the spacecraft will be handled as described in section 3 below.

2.8 IPAC shall partition individual timeline files such that all files start with an instrument ICTERM command and end with an ICINIT command. In the event that the nominal file boundary (GMT noon) does not naturally result in the ICTERM and ICINIT commands being placed as such then IPAC shall extend the file end time to include all instrument commands up to and including the next ICINIT. This will ensure that current file ends with an ICINIT command and that the subsequent file starts with and ICTERM command.

Additionally, IPAC shall extend the file boundary to include the next ICTERM, Maneuver, ICINIT command triplet in the event that the nominal file boundary occurs within 4 seconds of an ICTERM command. Science timeline partitioning is depicted in Figure 1-3.

2.9 Science timeline files (each spanning a 24 hour operational period) shall not contain more than 760 commands - or 380 commands per 12 hour operational duration. This is to assure sufficient command space (with margin) for spacecraft management commands inserted by the MOT into each command load. During L&EO/IOC operations the maximum command volume for a single science timeline file will be 690 - or 345 per 12 hour operational period.

3 MOT Science Timeline Processing and ATS Load Generation

3.1 The MOT will regularly monitor for the notification of new timeline set availability. Upon receipt of a notification message the MOT will respond by first retrieving the new timeline sets and then transmitting to IPAC an acknowledgement message. The acknowledgement shall include the name of the timeline set retrieved planned uplink time of the ATS load generated from the first file of the set. Notification shall be via email and also by the WIRE Electronic Forum during L&EO/IOC operations.

3.2 The MOT will perform science timeline validation and ATS load processing according the schedule shown in Table 2-1. Typical daily processing will consist of timeline validation and the creation of two ATS loads nominally containing 24 hours (12 hours for each load) of science instrument and spacecraft commands. The MOT will also validate the next timeline file in the set (valid for the following 24 hour period) and generate the next two ATS loads. This is to assure that, at a minimum, the subsequent loads are available in the event IPAC was unable to complete the next expected timeline delivery according to the pre-planned delivery schedule. If any validation or load generation fails then the MOT will automatically attempt to validate the remaining files in the set and report to IPAC all noted errors and warnings. This notification will also inform IPAC what timeline set was eventually used to generate the ATS load needed for the next uplink opportunity. Notification will be via email and telephone.

3.3 The MOT will generate ATS loads each day of the normal work week (i.e. Monday – Friday). Prior to the weekend the MOT will pre-generate ATS loads for use on Saturday, Sunday, and Monday since IPAC will not be delivering timelines during the weekend.

3.4 For the L&EO/IOC mission phase the MOT will generate at least 3 ATS loads for the buffers expected to be free when the next two station contacts occurs in which the loads would be available for uplink. The remaining timeline files in the set will also be validated for the same reasons as cited above. Load generation and timeline validation will be performed on a daily basis as soon as possible after receipt by IPAC of an updated timeline set taking into account the staffing plan in effect at the time.

3.5 The MOT will generate ATS loads in order to ensure that ICTERM, Maneuver, ICINIT command triplets are processed with the same ephemeris. This will be accomplished by processing each 24 hour timeline file with the same ephemeris and assuring that each ATS load period end time is extended to ensure that the load ends with an ICINIT command and the subsequent load file starts with an ICTERM command (for files whose end/start times are the nominal noon GMT boundary). An outline of ATS load processing to accomplish this is shown in Figure 1-3.

3.6 Total command volume for each 12 hour load cannot exceed 400 commands. In the event that the command volume exceeds 400 commands due to the input science timeline containing more than its maximum allowance (as defined in Section 1) then the MOT will mark the load and timeline as invalid and notify IPAC. Notification will be via email and telephone. IPAC must then re-generate the timeline to meet the maximum command limit guidelines set forth here prior to load generation and uplink. During the L&EO/IOC mission phase violations of maximum command volume limits will likely be dealt with by deleteing science commands (with IPAC approval) from either the beginning or end of the load as needed.

3.7 The MOT will always use the most recent ephemeris and flight dynamics products in the generation of ATS loads including , if practical, delaying ATS load generation until a product update has occurred. This will result in an acsending node utilization latency for each day of the week as outlined in Table 2-1.

3.8 The MOT will deliver to IPAC science timeline validation, integrated print, and other reports according the requirements outlined in Reference 1. Reports will only be created and sent to IPAC for the timeline files that are generated into ATS loads and for those that are validated as a precautionary step.

4 ATS Load Uplink Schedule

4.1 Each day of the mission (7 days/week) the MOT will upload two 12 hour ATS loads during a single station contact (pass) approximately 18 hours prior to their start of execution. Combining the IPAC science timeline delivery and the ATS load generation and uplink schedule result in the science timeline utilization latencies for each day of the week as shown in Table 2-1.

4.1.1 For Monday-Friday the first station contact will occur roughly from 2 pm to 4 pm Eastern Time while for the weekends it will occur roughly from 9 am to noon. The second station contact will be scheduled to occur early evening Eastern Time of every mission day and will be used as a backup commanding opportunity to complete daily ATS load and other command activities as needed.

4.1.2 If the daily ATS load and/or other activities have not been completed by the second contact the MOT will schedule additional (contingency) contacts to complete all planned activities for the day. In this event the MOT would have approximately 12 hours after the second pass to schedule the needed contingency contacts prior to the expiration of the current set of ATS loads onboard the spacecraft. Figure 1-1 and Table 2-1 summarizes the daily load generation and uplink activities.

4.1.3 The MOT will process and uplink the ATS load generated from the most current IPAC science timeline input providing ample time for complete quality and assurance checks prior to uplink. The MOT will not require final uplink approval from IPAC but will assume that all science timelines sent to the MOT are to be uplinked and that the most recent timeline set shall supersede previous revisions. In the event that an ATS load that has been recently uplinked is superseded by an IPAC update, then the MOT will generate and uplink the updated load overwriting the existing ATS buffer contents where the old revision resided. The MOT will schedule a contingency pass, if necessary, to assure that the updated load is uplinked to the spacecraft prior to execution start.

4.2 For the L&EO/IOC mission phase the MOT will nominally follow the normal operations phase of station contacts and ATS loading as cited above with several exceptions:

4.2.1 ATS loads will be uplinked approximately 6-8 hours prior to start of execution instead of ~18 hours.

4.2.2 The MOT will always update all buffers not currently executing with latest science timelines inputs received from IPAC. This implies that the MOT, upon receiving a timeline update from IPAC, will generate loads for the 3 ATS buffers expected to be free during the next two station contacts in which the loads could be uplinked and overwrite those buffers accordingly. Updating the ATS buffers in this fashion will be performed, as possible, according the current staffing plan in effect.

4.2.3 Additional passes will enable, as permitted by the current staffing plan in effect, updating of already loaded ATS contents in the event of science timeline updates issued from IPAC. Figure 1-2 summarizes the daily ATS load generations and uplink activities during the L&EO/IOC mission phase.

4.3 Combining the science timeline delivery and ATS load generation and uplink schedules results in a science timeline commitment schedule (depicted in Table 2-2 for normal and L&EO/IOC operations) which shows the days for which timeline segments are automatically committed for upload and execution on-board the spacecraft upon receipt of

the timeline file set by the MOT.

4.4 The MOT will maintain a complete and accurate ATS activity log of the time of uplink of each ATS load, ATS buffer updates, manual ATS buffer switches prior to current ATS expiration, and the corresponding science timeline file(s) used as input during all phases of the mission. These records will be forwarded to IPAC (via FAX) at least 3 times per week (on Monday, Wednesday, and Friday) during the normal operations phase and at least daily during L&EO/IOC operations. If possible, the MOT will also utilize the electronic notebook maintained by IPAC as an ATS activity log repository.

5 Station Contact Schedule

5.1 The MOT will schedule station contacts to support checkout and operation of the WIRE spacecraft according to the following schedule:

Table 5-1 Station Contact Schedule

Mission Phase	Timeframe	Contacts/Day
L&EO/IOC	Days 1-3	28 (1-2 per orbit)
L&EO/IOC	Days 4-7	8
L&EO/IOC	Days 8-20	4-6
Normal Ops	Days 21-End	2-3

5.2 The MOT will schedule additional contacts as necessary to support spacecraft and instrument contingency and anomaly investigation and resolution.

6 Science Data Latency

The coupling of science timeline generation and delivery by IPAC, MOT processing of ATS loads, uplink of loads to the spacecraft, processing of resulting science data by the DPS, and transport back to IPAC result in the following approximate data latency duration for each mission phase:

Table 6-1 Science Data Latency

Mission Phase	Timeframe	Data Latency
L&EO/IOC	Days 1-3	~8 hours
L&EO/IOC	Days 4-7	~13 hours
L&EO/IOC	Days 8-20	~18 hours
Normal Ops	Days 21-End	~49 hours

Data latency is defined as the time duration from the completion of science timeline generation by IPAC until science data, resulting from execution of the timeline on-board the spacecraft, is received back at IPAC.

7 MOT Data Archiving

7.1 The MOT will store all received VC0 and VC1 data until end of mission independently of the ground stations, DPS, and IPAC. VC2 data will not be received and thus not stored at the MOC.

7.2 All data storage will be in raw format.

8 MOT Spacecraft Management

8.1 Spacecraft Clock

8.1.1 The spacecraft clock will be maintained to within 1 second of UTC.

8.1.2 During launch and early orbit operations (approx. mission days 1-20) the clock will updated during ground station contacts with no correlation to other ongoing spacecraft or instrument activities. These clock updates may occur during instrument science gathering.

8.1.3 During normal operations (approx. mission day 21 – end of mission) clock updates will be performed from the onboard ATS timeline to occur only during spacecraft slews in order to avoid updates during instrument science gathering operations.

8.1.4 Clock updates will be performed daily with expected delta values of 20-50 milli-seconds.

8.1.5 The MOT will not notify IPAC of the amount clock adjustment unless the adjustment exceeds 250 milli-seconds. In that case notification of the amount of adjustment will be made via email.

8.2 Solid State Recorder

8.2.1 Each file of the solid state recorder shall be configured for WRAP mode during all phases of the mission.

8.2.2 During each ground station contact with the spacecraft the OLD data partition of each file will be released by purposely setting the OLD partition pointer to the PREV pointer. This action is necessary in order to prevent science data loss during recorder read operations that would occur during ground station contacts. A consequence of this will be the inability to access data in the OLD partition of each file once it is released.

8.2.3 The expected data storage capacity of the recorder during the normal ops mission phase is ~36 hours. That is, data can be stored to the recorder for ~36 hours prior to the NEW data partition (data recorded since the last station contact when a dump was performed - this data has not yet been downlinked) of each file being overwritten. Likewise, data can only be stored for a period of approximately 24 hours prior to the PREVIOUS data partition (containing the data set from the last station contact when the recorder was dumped) being overwritten.

8.3 ATS Buffers

8.3.1 The MOT will nominally load to and execute the ATS buffers in a repeating sequential manner of: A->B->C->D->A…

8.3.2 During the L&EO/IOC mission phase the MOT will use buffers A and B for timelines containing nominal targeting (i.e. IOC timelines) and buffers C and D for special activities in which targets may be non-nominal (i.e. Gyro Calibration, FDH Constraint, and Cover Eject timelines). Manual switching among buffers prior to current buffer execution will be performed in order complete spacecraft and instrument checkout activities.

8.3.3 The spacecraft will have ~18 hours of valid on-board commands residing in the ATS buffers at the time of each daily load uplink. During the L&EO/IOC mission phase there will be at least 24 hours of on-board commands residing in the buffers at the time of each load uplink (2-3 load uplinks expected per day). This amount of on-board command reserve is considered by the MOT to provide adequate protection against ATS load expiration in the event of missed station contacts.

8.4 Flight Software (FSW) Tables

FSW tables include RTS, ACS and C&DH tables that may need to be updated during the mission for whatever reason. All such table updates will be performed in the same manner which involves the following steps:

1) Loading the table to RAM memory,
2) Verifying the table was loaded properly via monitoring telemetry
3) Dumping the table and comparing the dump and load image as a double check to verify the table was properly loaded, and
4) Committing the table (if needed) to EEPROM after sufficient usage has accrued to verify its operational integrity.

9 Monitoring of Instrument Health and Safety

9.1 The MOT will be responsible for basic instrument health and safety monitoring. Limit monitoring of instrument telemetry will be performed such as monitoring that WIE and FPA voltages, currents, and temperatures and temperatures of the WIE and cryostat are within green limits.

9.2 IPAC will be responsible for performing telemetry limit monitoring as a backup to MOT monitoring in addition to any other telemetry analysis and/or monitoring needed to detect deviations from nominal expected performance.

10 Spacecraft and Instrument Anomalies

10.1 The MOT will immediately notify IPAC and the Project in the event of any spacecraft and/or instrument anomalies. Such anomalies include spacecraft leaving Stellar Point mode, instrument cryostat temperatures out of limits, solid state recorder multi-bit errors, science commands rejected, etc.

10.2 The MOT and IPAC will notify the other of any human errors made by their respective team's actions that resulted in anomalous spacecraft behavior and/or that required contingency operations to remedy.

10.3 All anomalies will be documented in the VMOC (Virtual MOC) anomaly reporting system accessible via the internet (password required). IPAC will be given access to the VMOC system for review of all such anomalies. Notification of all anomalies shall be as soon as reasonably possible after anomaly detection and emergency corrective action is performed (if needed) and be via email and telephone.

11 Flight Software Table Management

11.1 Protocol for FSW Table Updates

Any request for a FSW Table modification, from whatever source and for whatever reason, must be forwarded to the MOT with IPAC, the Project System Engineer, and software maintenance group copied. Table changes involving spacecraft operation only (i.e. do effect the instrument or science gathering operations) must be approved by the System Engineer and the MOT Operation Director prior to uploading. Table changes effecting instrument operation must be approved by IPAC (these will likely be generated by IPAC and approval is thus implied, e.g. an instrument RTS or the ACS Dither Table). Upon approval, the requested table updates will be performed by the MOT and uploaded to the spacecraft. IPAC, the Project System Engineer and software maintenance group will be notified of the exact time of and nature of the changes as confirmation that they have been put into effect.

11.2 Post Launch RTS Utilization and Allocation

The following RTS's will become available for MOT and IPAC use following instrument cover ejection:

Table 11-1 Post-Launch RTS Utilization

RTS #	Original Assignment	New Assignment
1	SCS Initialization	S/C Operations: MOT
2	Pre-Drop Config.	S/C Operations: MOT
3	Drop Config.	S/C Operations: MOT
4	Spare ASE #4	S/C Operations: MOT
5	Spare ASE #5	Science Operations: IPAC
6	S/C Shutdown	Science Operations: IPAC
7	Spare ASE #7	Science Operations: IPAC
12	Pegasus Separation	Science Operations: IPAC
13	Pyro Arm	Science Operations: IPAC
15	Solar Array Deploy	Science Operations: IPAC
28	Turn OFF Primary Vent Deploy	Science Operations: IPAC
32	Instrument Cover Ejection	Science Operations: IPAC

11.3 Documentation and Archiving of FSW Table Contents

11.3.1 The MOT will maintain a complete and accurate FSW table utilization and update log which documents the exact time and nature of each table update on the spacecraft. Complete electronic and paper records of the current and past contents of each table will be maintained by the MOT and forwarded to IPAC upon request. IPAC will be automatically be notified after any RTS or FSW table update effecting instrument

operations. Notification will be via email and include the original and updated table(s) as attachments. The updated table(s) shall be the image(s) dumped from spacecraft RAM after the table has been loaded.

11.3.2 The MOT will utilize the Mission Planning System (MPS) to maintain a complete and accurate spacecraft memory model of all RTS's. The memory model will be updated to reflect all changes made to spacecraft RTS contents. All load and dump files associated with such changes will be archived. The flight software maintenance group shall also update the on-line flight software documentation web site with the RTS updates.

11.3.3 A complete and accurate memory model of all Non-RTS FSW tables will be maintained in the MOC and managed under a configuration management plan approved by the MOT and the software maintenance group.

12 Data Recovery Guidelines

12.1 The MOT will routinely perform accounting of VC1 and VC2 data independently of the DPS to assure that all data dumped during a ground station contact is received at the station. No other accounting or quality evaluation will be performed.

12.2 The MOT will be capable of recovering missing data by either re-dumping the entire PREVIOUS data partition of any file or re-dumping portions of the PREVIOUS partition of any file by knowing the time span of the missing data. Generally, re-dumping an entire PREVIOUS partition is preferred. The MOT will not be capable of re-dumping the OLD partition (or any portion) since it is routinely cleared at each station contact.

12.3 In the event that the MOT, DPS, or IPAC determines that a re-dump of the PREVIOUS data partition of any file is necessary then the MOT will schedule a contingency contact to perform the re-dump. The re-dump must occur within ~24 hours of the contact where the missing data occurred. Missing data may result from several causes including a missed station contact due to a ground station misconfiguration or a bad space to ground RF link.

12.4 The MOT will automatically initiate action to recover the PREVIOUS data partition in the event that missing data exceeds 10% of the expected volume during a station contact. The percentage of missing data will be determined from the total number of telemetry frames that should have been received at the station (as determined from spacecraft telemetry) to the number of actual frames received at the station (as determined by station frame accounting).

12.5 Missing data due to ground network problems or station or DPS equipment problems will be recovered via a re-FTP transfer from the station to the DPS and MOC after problem

resolution. No re-dump of telemetry from the spacecraft will be required.

12.6 The MOT will log any occurrence of missing data outside of normal expected ranges regardless of data recovery actions taken. Log entries will be made to the VMOC system and the MOT station contact logbook. IPAC will be notified via the VMOC system of any such occurrences.

13 Staffing

13.1 MOT

Table 12-1 MOT Mission Staffing Plan

Mission Phase	Timeframe	Staffing
L&EO/IOC	Days 1-7	24 hours/day, 7 days/week
L&EO/IOC	Days 8-20	12 hours/day, 7 days/week
Normal Ops	Days 21-End	8 hours/day, 5 days/week 2 hours/day, weekends

The MOT will operate the spacecraft according the above staffing plan regardless of planned or un-planned holidays or administrative leave.

13.2 IPAC

Table 12-2 IPAC Mission Staffing Plan

Mission Phase	Timeframe	Staffing
L&EO/IOC	Days 1-7	24 hours/day, 7 days/week
L&EO/IOC	Days 8-20	12 hours/day, 7 days/week
Normal Ops	Days 21-End	8 hours/day, 5 days/week

14 Contact List

SMEX Personnel Listing		
Name	**Responsibility**	**Telephone Numbers**
Albert, Cheryl	MOT	Office (301) 286-0674 Pager (301) 239-4843 Home
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IPAC Personnel Listing		
Name	**Responsibility**	**Work Numbers**
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Hacking, Perry	WIRE Instrument Principal Investigator	Office (626) 397- 9525 Pager Home
Henderson, David	Science Operations Lead	Office (626) 397- 7239 Pager Home
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Lo, Steve	Network	Office (626) 397- 9511 Pager Home
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Luchik, Tom	WIRE JPL Project manager	Office (626) 397- 7160 Pager Home
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